GEAR

This invention relates to a gear, and is more particularly concerned with an internal gear for use in applications where corrosion of the gear teeth present a problem. Such a problem is encountered with gears used in rotary actuators, particularly aircraft actuators, and more particularly actuators of the geared hinge type which are used for operating the leading edge flying control surfaces on certain types of aircraft

In EP-A-0384629 published on 9 Aug. 1990, there is described an article which is intended to engage against another article with relative movement therebetween, the article comprising a body having a surface region which (a) engages with said another in use and (b) is defined at least partly by a cladding, said cladding being connected to the material of the body by diffusion bonding and being harder than the material of the body. In one embodiment, the body is formed of tough, high tensile iron or steel, e.g. precipitation-hardened stainless steel and the cladding is formed of a harder material such as hard stainless tool steel or a hard non-ferrous alloy, e.g. a cobalt-based alloy such as is sold under the trade mark Stellite.

In the above-mentioned EP-A-0384629, the article may be a gear having gear teeth on an external or an internal surface region of the gear body.

It is an object of the present invention to provide a gear having teeth which not only possess the required fatigue resistance but also possess a high corrosion resistance.

According to one aspect of the present invention, there is provided a gear comprising a body having gear teeth, characterized in that the gear teeth are formed of a cobalt-based alloy which has been hot isostatically pressed from a powder and which consists of 10 to 35 wt % chromium, 0–22 wt % nickel, 0–20 wt % tungsten, 0–20 wt % iron, 0–10 wt % vanadium, 0–10 wt % molybdenum, 0–6 wt % niobium, 0–3 wt % silicon, 0–3 wt % carbon, 0–3 wt % boron, 0–1 wt % manganese, the balance, apart from impurities, being cobalt.

Preferably, the cobalt-based alloy consists of 26–29 wt % chromium, 5–9 wt % tungsten, 1–1.8 wt % carbon and 0–6 wt % niobium, the balance, apart from impurities, being cobalt.

One preferred embodiment of the alloy consists of 26 wt % chromium, 5 wt % tungsten, 1 wt % carbon and 6 wt % niobium, the balance, apart from impurities, being cobalt.

Another embodiment of the alloy consists of 29 wt % chromium, 9 wt % tungsten and 1.8 wt % carbon, the balance, apart from impurities, being cobalt.

In one embodiment, the body is formed integrally with the gear teeth out of the same alloy in the same hot isostatic pressing operation.

In another embodiment, the body is formed of a suitably corrosion-resistant material, e.g. stainless steel, particularly precipitation-hardened stainless steel. The gear teeth are preferably diffusion bonded to the body. Diffusion bonding may be effected by means of a hot isostatic pressing operation in which the gear teeth are formed from the powdered alloy, or the gear teeth may be provided on a ring of hot isostatically pressed alloy powder which is subsequently diffusion bonded to the body of the gear preferably by means of a hot isostatic pressing operation.

The alloy used is most preferably an alloy of the type which is sold under the trade mark Stellite, e.g. Stellite 6. The powered alloy is typically produced from the melted alloy by an atomisation process.

The use of such materials to produce gear teeth is particularly surprising since the microstructure of a compact material formed from the alloy powder by conventional sintering does not indicate that such material would be suitable for use as a gear material in a highly stressed application. By "conventional sintering" is meant pressing the powder in a die set at 500–1000 MPa to form a "green" preform, and then heating the green preform at 1000°–2000° C. for up to several hours.

It has been discovered that the hot isostatic pressing operation on the alloy powder produces a material which has an unexpectedly good fatigue strength, making it particularly suitable to withstand the rigorous conditions which exist in service of a highly loaded gear for an aircraft application where the weight and size are critical and stress is therefore relatively high.

By the term "hot isostatic pressing" is meant a process which involves the simultaneous application of heat and pressure by means of a gaseous medium (usually argon) to the material being hot isostatically pressed. The hot isostatic pressing operation is usually effected at a pressure of greater than 50 MPa, more usually greater than 100 MPa, and typically at a pressure of about 200–300 MPa at a temperature in the range of approximately 900°–1100° C. for a period of about 1 to 8 hours, typically of the order of 4 hours. The application of heat and pressure simultaneously in the hot isostatic powder pressing process eliminates all porosity from the resulting compact material which becomes substantially fully dense. Air contained in the interstices between the particles is compressed and at the high temperature prevailing, its constituents dissolve in the material of the particles. Sequential application of pressure and heat as in conventional powder metallurgy sintering does not achieve this result and porosity is relatively high.

In spite of its high strength properties, the shape which has been prepared by hot isostatically pressing the alloy powder is machinable. Accordingly, it is within the scope of the present invention, not only to form the teeth during a hot isostatic powder pressing operation, but also to use a hot isostatic powder pressing operation to form a blank in which the teeth may be partly formed, and then to subject such blank to a machining operation to produce at least the final form of the teeth.

Most preferably, the particle size of the alloy powder subjected to hot isostatic pressing is such that it passes through a 150 μm sieve.

The present invention is particularly applicable to epicyclic gears such as are used in the previously mentioned powered geared hinge actuators for aircraft leading edge flying control surfaces.

Accordingly, in another aspect of the present invention, there is provided a geared hinged actuator wherein at least one, and preferably all, of the gears are as defined above in the first aspect of the present invention.

The present invention also resides in the use of a hot isostatically pressed alloy powder in the manufacture of gear teeth using an alloy which consists of 10 to 35 wt % chromium, 0–22 wt % nickel, 0–20 wt % tungsten, 0–20 wt % iron, 0–10 wt % vanadium, 0–10 wt % molybdenum, 0–6 wt % niobium, 0–3 wt % silicon, 0–3 wt